



PREPARATION AND SPECTRAL CHARACTERISTICS OF Ce³⁺ ACTIVATED ALUMINO-BORATE BaAl₂B₂O₇**R. S. Palaspagar^{1,a)}, S. R. Khandekar², R. P. Sonekar⁴, S. K. Omanwar⁵**¹Department of Physics, Shivramji Moghe Mahavidyalaya, Kelapur (Pkd) Dist. Yavatmal-445001(M.S.), INDIA.²Department of Chemistry, Indira Mahavidyalaya, Kalamb, Dist. Yavatmal - 445401(M.S.), INDIA.⁴Department of Physics, G.S. College, Khamgaon, Dist: Buldhana (M.S.), INDIA.⁵Department of Physics, SGB Amravati University, Amravati-444602(M.S.), INDIA.^{a)}Corresponding author: rspalaspagar@gmail.com

ABSTRACT :

Ce³⁺ activated alumino-borate BaAl₂B₂O₇ was prepared via the solution combustion technique. The phosphor's phase purity and its emission properties were studied using powder X-ray diffraction pattern and photoluminescence spectroscopy. The photoluminescence properties of borate phosphors have been investigated on fluorescence spectrometer (F-7000). The Ba_(0.95)Al₂B₂O₇:0.05Ce³⁺ phosphor shows an intense blue emission peaking at about 420 nm upon 336 nm excitation. The CIE chromaticity coordinates for Ba_(0.95)Al₂B₂O₇:0.05Ce³⁺ were calculated from the PL spectra under 336 nm excitation in the CIE 1931 chromaticity diagram.

KEYWORDS: Alumino-Borates, Combustion Synthesis, XRD, Photoluminescence, LED.**1. INTRODUCTION**

Alkaline-earth aluminum borates have been taken interest in by scientists during the past decade because of their potential applications as luminescence hosts [1-3]. The phase of BaAl₂B₂O₇, is an example of alkaline-earth aluminum borates, was first described by Hu¹ner [4] following a study of the ternary system BaO–Al₂O₃–B₂O₃. It is characterized by having an association of BO₃ triangles, BaO₆ octahedra, and AlO₄ tetrahedra. The crystal structure of BaAl₂B₂O₇ has been reported in detail elsewhere [5]. Although the mechanical and electrical properties of BaAl₂B₂O₇ have been studied in detail by Macdowell [6]. Inorganic Borate host compounds doped with rare earth ions are the important classes of phosphors useful for LED based solid state light. Considering Ce³⁺ as a highly efficient activator, the Ce³⁺ emission spectrum usually consists of a broad band due to transition between the 4f¹ ground state and the 5d excited state configuration, and can occur from the ultraviolet to the red region of the electro-magnetic spectrum, depending on the different host lattices [7, 8]. Doped rare-earth ions such as borates have great potential in LED application due to their advantages of a low synthesizing temperature and good chemical and physical stability. Examples of these known Ce³⁺ doped borate phosphors are, Ca₃La₃(BO₃)₅:Ce³⁺ [9], NaBaBO₃:Ce³⁺ [10], NaSrBO₃:Ce³⁺ [11], NaCaBO₃:Ce³⁺ [12].

In the present work, we report synthesis and photoluminescence properties of BaAl₂B₂O₇:Ce³⁺. Their photoluminescence properties under the near-UV excitation were evaluated in detail.

2. EXPERIMENTAL

The Powder samples of Ba_(0.95)Al₂B₂O₇:0.05Ce³⁺ have been prepared by a solution combustion technique followed by heating combustion ash at 800 °C in air. The method is based on the exothermic reaction between the fuel (urea) and oxidizer (Aluminum Nitrate). The detailed description of the method was reported in our earlier work [13-20]. The stoichiometric amounts of Al(NO₃)₃.9H₂O, Ba(NO₃)₂, H₃BO₃, Ce₂O₃

and $\text{CO}(\text{NH}_2)_2$ used were of AR grade and the rare earth Ce_2O_3 (99.99% purity) used were from the Indian Rare earth. The stoichiometric amounts of the ingredients were thoroughly mixed in an Agate Mortar, adding little amount of double distilled water to obtain aqueous solution. The aqueous solution was slowly heated at lower temperature of 90°C to remove the excess water. The solution was then introduced into a preheated muffle furnace maintained at $(550 \pm 10)^\circ\text{C}$. The solution boils foams and ignites to burn with flame, a voluminous, foamy powder was obtained. The entire combustion process was over in about 5 min. The resulting fine powders were annealed in a slightly reducing atmosphere provided by burning charcoal at temperature 750°C for about 90 min. and suddenly cooled to room temperature. The samples are subjected to XRD analysis. PL measurements were performed on Fluorescence Spectrometer (Hitachi F-7000).

3. RESULTS AND DISCUSSION

The XRD pattern of the polycrystalline powder samples of the phosphor $\text{Ba}_{(0.95)}\text{Al}_2\text{B}_2\text{O}_7:0.05\text{Ce}^{3+}$ have been analyzed for the structure confirmation. The powder XRD pattern of the phosphor was compared with the standard JCPDS data files and found to be in good agreement with the ICDD File No. 01-086-2168 (Fig. 1).

Fig. 2 shows the typical PL excitation and emission spectra of $\text{BaAl}_2\text{B}_2\text{O}_7:\text{Ce}^{3+}$ (5 mol.%). The excitation and emission spectra found in Fig. 2 are corresponding to the electronic transitions between $4f^1$ ground state and $5d$ -multiplets of Ce^{3+} . The ground state configuration $4f^1$ of Ce^{3+} is split into $^2F_{5/2}$ and $^2F_{7/2}$ levels by spin-orbit interaction [21]. The phosphor is excited at 336 nm is attributed to electronic excitation from $4f^1$ ground state to $5d$ -multiplets of Ce^{3+} . By the excitation of 336 nm wavelength, the phosphor has emission center at 420 nm. The emission peak at 420 nm in the (blue) visible region is attributed to the transition $5d \rightarrow ^2F_{7/2}$ of Ce^{3+} . The excitation and emission peaks are characteristic spectra of $5d$ - $4f$ transition of Ce^{3+} . The CIE chromaticity coordinates for $\text{Ba}_{(0.95)}\text{Al}_2\text{B}_2\text{O}_7:0.05\text{Ce}^{3+}$ were calculated from the PL spectra under 336 nm excitation and marked with a star in the CIE 1931 chromaticity diagram in Fig. 3. The chromaticity coordinates (x,y) of this phosphor are calculated to be (0.1714,0.0051), respectively, which indicates that the emission color of the as prepared phosphors is located in the deep blue region.

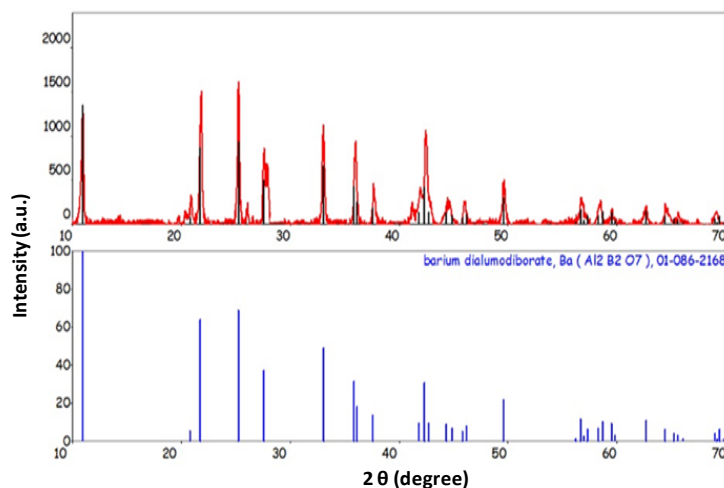


Fig. 1. XRD pattern of $\text{Ba}_{(0.95)}\text{Al}_2\text{B}_2\text{O}_7:0.05\text{Ce}^{3+}$ phosphor (ICDD Card No. 01-086-2168).

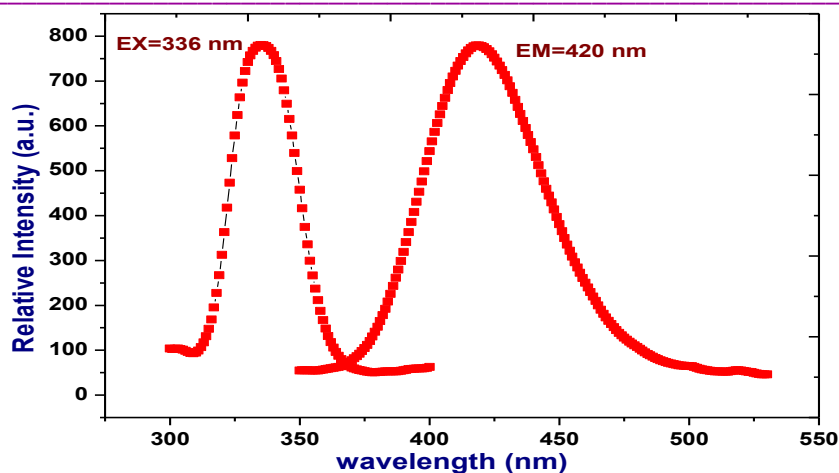


Fig. 2. Excitation & Emission Spectra of $Ba_{(0.95)}Al_2B_2O_7:0.05Ce^{3+}$ phosphor.

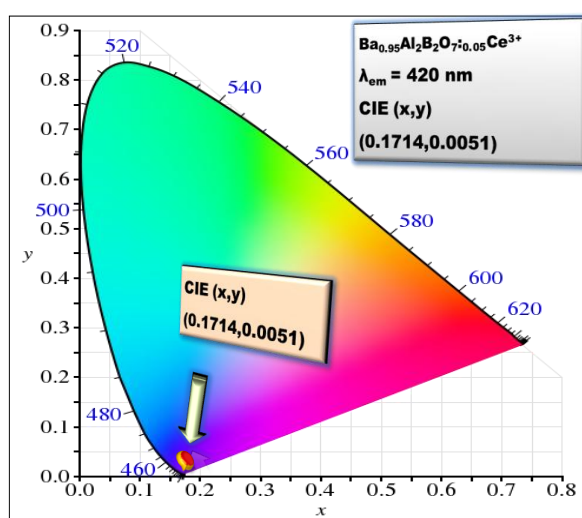


Fig. 3. Chromaticity coordinates of $Ba_{(0.95)}Al_2B_2O_7:0.05Ce^{3+}$ phosphor in the CIE 1931 chromaticity diagram.

4. CONCLUSIONS

The inorganic borate host phosphor $Ba_{(0.95)}Al_2B_2O_7:0.05Ce^{3+}$ was prepared by a low cost, simple and time saving solution combustion technique. The powder XRD pattern confirms the structure of prepared $Ba_{(0.95)}Al_2B_2O_7:0.05Ce^{3+}$ phosphor. The phosphor yielded the highest PL intensity at 5 mol% of Ce^{3+} concentration. The PLE spectrum of $Ba_{(0.95)}Al_2B_2O_7:0.05Ce^{3+}$ consists the strongest absorption peak is centered at about 336 nm. The phosphor exhibits a blue emitting band peaking at 420 nm upon 336 nm n-UV excitation. The optimal doping concentration of Ce^{3+} is 5 mol%. The relatively high activation energy results in a good thermal stability for this phosphor. The chromaticity coordinates (x,y) of this phosphor are calculated to be (0.1714,0.0051), respectively, which indicates that the emission color of the as prepared phosphors is located in the deep blue region. The $BaAl_2B_2O_7:Ce^{3+}$ phosphors may be potential blue-emitting components for UV excited w-LEDs.

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